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Analysis of Water Injection in Fractured Reservoirs Using a Fractional-Derivative-Based Mass and Heat Transfer Model

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Abstract

© 2014, International Association for Mathematical Geosciences. This research proposes a numerical scheme for evaluating the effect of cold-water injection into a geothermal reservoir. A fractional heat transfer equation (fHTE) is derived based on the fractional advection–dispersion equation (fADE) that describes non-Fickian dispersion in a fractured reservoir. Numerical simulations are conducted to examine the applicability of the fADE and the fHTE in interpreting tracer and thermal responses in a fault-related subsidiary structure associated with fractal geometry. A double-peak is exhibited when the surrounding rocks have a constant permeability. On the other hand, the peak in the tracer response gradually decreases when the permeability varies with distance from the fault zone according to a power law, which can be described by the fADE. The temperature decline is more gradual when the permeability of surrounding rocks varies spatially than when they have a constant permeability. The fHTE demonstrates good agreement with the temperature profiles for the different permeabilities of surrounding rocks. The retardation parameters in the fADE and the fHTE increase with the permeability of the surrounding rocks. The orders of the temporal fractional derivatives in the fADE and the fHTE vary with the permeability patterns.

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Keywords

Fault zone, Fractional advection–dispersion equation, Geothermal reservoir, Thermal breakthrough, Tracer test